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INVESTIGATION OF A RELIABLE ACOUSTIC PATH (U)

C. L. Buchanan and Isidore Cook

SOUND DIVISION

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NAVAL RESEARCH LABORATORY
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SOUND DIVISION

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ABSTRACT

The U. S. Naval Research Laboratory is conducting research aimed at reduction of the variability of sonar performance due to varying thermal conditions. One of the methods showing great promise is to move the transducer away from the surface boundary. Limited tests have been performed at depths down to 3000 feet. Preliminary results of these tests are reported.

PROBLEM STATUS

This is a preliminary report of experiments conducted near San Juan, P. R. in March 1957. Additional tests will be conducted as facilities become available.

AUTHORIZATION

NRL Problem S05-16
Project No. NR 443-000
CNO Project Bu/S343/J15-11. Priority "A"

INVESTIGATION OF A RELIABLE ACOUSTIC PATH

BACKGROUND

Improvements in Sonar equipments since World War II have resulted in a considerable extension in detection range in surface-bounded ducts. This extension of detection range in the channel has not resulted in a similar extension below the duct or in those cases where no duct exists. The situation today then, as previously, is that sonar performance fluctuates at the mercy of the "Sonar Conditions." It is paradoxical but true that under the very conditions which yield the largest detection ranges, due to well developed surface-bounded ducts, the detection range to a submarine below the duct may be so short as to be of little value. The high probability that any potential enemy would employ submarines of modern design, capable of great endurance, and deep submergence for extended periods of time, demands a review of sonar techniques in search of methods of improving the sonar detection capabilities below the duct and methods of reducing the variability of detection ranges due to variations in "Sonar Conditions."

The normal gross effect of the temperature-pressure characteristics of the ocean is to bend all sound rays originating near the surface downward away from the surface. Since all rays from shallow sources leaving at angles above the horizontal are reflected downward from the surface, they effectively leave at negative angles.

These two effects leave a minimum of sound in the surface region as range increases. This gross effect exists at virtually all times in all locations. The effect of surface mixing due to wave action may overcome the gross effect to some extent. Actually under this condition only sound rays within about ±2° of the horizontal are affected sufficiently to overcome the gross effect. Under even the best surface-bounded-duct conditions all rays leaving the shallow source at angles of more than ±2° are bent downward and out of the channel.

Experience has shown that with high-powered-sonar equipment such as the NRL LRS 2-5 system operating at 5 kc, bottom reverberation maxima were obtained consistently at ranges of 10-15 kyd with water depths of 1000 to 1500 fathoms. This is certainly a graphic example of the normal refraction condition.

If the depth of the ocean is sufficient, the gross downward refraction previously considered is overcome by the pressure effect and the sound rays are gradually bent upward resulting in the well established "convergence zone." This path could be

considered a reliable one if oceans were uniformly deep enough and if the surface temperature was uniformly and sufficiently low. For example: Tests in 2700 fathoms of water with a surface-water temperature of 80° F (made by NRL between Norfolk and Bermuda in August 1956) showed that these conditions did not produce a well developed convergence condition. Calculations indicate that the surface temperature would have had to be 10° cooler or the ocean about 800 fathoms deeper for a well developed convergence zone condition to exist.

The above example is not intended to discredit the usefulness of this path but rather to illustrate that much more information is needed from a wider selection of areas before its practical utility can be assessed.

Note however that this path does cover all target depths when it exists and for this reason if for no other it is of great interest.

The main disadvantage to the convergence zone path is the requirement for very deep water, and this requirement for ocean depth increases as the surface temperature increases.

A second way of circumventing the effect of the normal gross downward bending effect of the ocean is to use the bottom of the ocean as a reflector. This method is fraught with many difficulties since the depth, type and formation of the bottom are all variable. This method however may be useful and much work needs to be done to clearly establish the practical utility of this path.

A third method of circumventing the gross downward bending of sound rays is to place the sonar equipment deep within the medium so that the natural ray paths actually carry the sound to the desired ranges (see reference 1). The range at which this path reaches the surface as a function of source depth is illustrated in Figure 1. This method has the advantages of not requiring excessive depth, and not involving an unknown boundary. Its disadvantages are: No focusing effect occurs so that losses probably will be almost equal to spherical spreading (this may be somewhat lessened by reflections from the surface), surface reverberation may be so high as to mask any submarine echoes, and, the difficulty of actually putting the essential parts of the sonar system at the required depth in such a way as to be useful in practice.

Of the three possible disadvantages mentioned above, the only one which could prohibit the use of this path from a theoretical standpoint, is that of surface reverberations. Little has been done in the way of independent measurement of surface reflections at high angles of incidence and reflection. Without such measurements it is not feasible to attempt the design of a practical system.

It should be observed that surface reflection information would be of great value in considering limitations of both the convergence-zone path and the bottom reflected path, as well as, the path from deep sources.

In view of the above considerations, the logical approach to this problem appeared to be collection of surface reverberation data as a function of angles of arrival and reverberation. While one might consider that data where the angle of reverberation is 180° minus the angle of arrival would be sufficient, it was felt that a more thorough study which separately accounted for the angle of arrival and the angle of reverberation would permit better understanding of the mechanism of reflection under various situations and might lead to better theoretical predictions. Figure 2 illustrates this approach.

As a compromise between extension of the path to its ultimate value of 17 miles (which would require a source depth of about 2000 fathoms) and the insignificant gain to be obtained by source depths of a few hundred feet, it was decided to set the realistic range objective of 10,000 yards as a goal. This range requires about 3000-feet source depth if our understanding of the path is correct.

The plan of attack involved modification of an experimental hoisting equipment and construction of a duplicate to handle a 6000-pound fish to a depth of 3000 feet (see appendix A). These equipments were to be installed on two vessels for the desired measurements.

The method of operation planned was to have the two ships steaming slowly on parallel courses at some selected separation. One ship would tow an omnidirectional transducer at a depth of 3000 feet. Short "pings" transmitted from this transducer would intersect the surface in a circular annulus expanding with time. The second ship would tow, at 500 to 1000 feet, a transducer having a narrow horizontal beam-width but being omnidirectional in the vertical plane (a horizontal line hydrophone).

The portion of the sonified annulus "seen" by this line hydrophone would approximate a rectangle whose area could readily be computed. By making one-way measurements at various selected ranges and receiver depths, a family of curves could be obtained which would permit computation of the scattering effect of the surface in all directions. Figure 2 illustrates the general form to be expected in a typical situation.

While enroute to San Juan, the area selected in which to make the measurements, one of the ships, USS EAG 398, encountered heavy seas and suffered a casualty to the after door cover of its center well forcing it to return immediately to its home port for repairs. The studies described previously could not, of course be accomplished with only a single ship. It was decided however to concentrate instead on certain basic measurements, such as self-noise levels, rather than to abandon the tests completely. In fact, it was believed that towing with a "length of line out" of 1000 feet would in itself be an accomplishment. (The equipment and operations of the ship will be described in detail in later sections of this report.)

EQUIPMENT

The measurements made in the field in the San Juan area were accomplished using the services of the USS ROCKVILLE (PCER 851). All electronic equipment was installed in the sonar laboratory spaces located on the main deck aft, while the hoist equipment was on the 01 deck arranged for over-the-side towing on the starboard side approximately amidships.

The hoist, Figure 3, consists of a drum which is cylindrical and about four feet in diameter. Because of the long length of cable six layers are wound on the drum with the aid of a level-wind mechanism. The hoisting speed is approximately 50 feet per minute. A 15-hp motor with reduction gear provides the motive power. A "length of line out" counter is provided. Hoisting is accomplished by utilizing a carriage and track system. Beginning at the waterline, the tracks are attached to the hull and extend up to the deck level and lead the carriage to another portion of similar but separate tracks that are part of the deck equipment. The carriage, guided by the tracks, is hoisted and lowered with the fish, encompassing it fore and aft by means of girdling arms. Sheaves to guide the towline are attached to th carriage; the towpoint is at these sheaves. On the deck, the motor and reducti n gear, the cable drum, carriage and fish are mounted on a "garden gate." The gate is rotated about a vertical post forward while the after portion is supported by wheels on curved tracks. A manual drive is provided to move the gate equipment from the towing position parallel to the ship's side, to the stowed position normal to the ship's side.

The towline is a 5/8-inch diameter special electrical cable. There are three conductors of No. 14 AWG stranded wire and three conductors of No. 24 AWG stranded wire within a 0.04-inch-thick plastic sheath. Over-all is applied two reverse layers of preformed, galvanized steel wired 0.06 inches in diameter. The cable has a minimum breaking strength of 25,000 pounds. Within the towed body the cable terminates in a friction-type socket which grasps the steel wires while permitting unobstructed entry of the electrical cable. A 3300-foot length of cable was used without fairing or any other device to reduce vibration and drag.

The towed body, or fish, Figure 4, is the streamlined housing for the transducer. It is assembled by bolting a complete 60-inch rubber dome upside down to a solid lead keel shaped like the bottom of a 60-inch dome. This results in a body having the shape of a streamlined cylinder of EPH (ellipse, parabola, hyperbola) contour, with top- and bottom-half bodies of revolution. Exclusive of tail fins, the housing is 60 inches long, 46 inches high and 24 inches wide. Vertical and horizontal tail fins are made of 1/4-inch aluminum plate. This assembly extends the length of the towed body to 70 inches. Trim tabs are provided for adjustment of the streaming. The housing is sound transparent in all directions except the bottom. In addition to the transducer, there is a combination junction and instrumentation box within the housing. Instruments are provided for sensing the pitch, roll and depth of the fish, and the temperature of the water. Also within this box are the electrical components necessary for tuning the transducer. The weight of the body is 6000 pounds.

At the first checkout of the hoist equipment at sea, it was found that the level wind mechanism did not function properly. Although the reason for the malfunction was not primarily due to the weight of the fish, after the mechanism had been repaired it was decided to conduct the operations in the San Juan area using a lighter fish weighing 3000 pounds. This fish is hydrodynamically identical to the heavier body; it differs in that a 60-inch rubber dome is used right side up, this dome having its keel filled with lead, with a bottom section of a similar dome used as a top cover.

The electronic equipment was of standard design; no special devices were used. For the driver, a commercial type 1-kw amplifier was employed. This amplifier has a frequency range of 200 cycles to 50 kilocycles and requires a minimum input signal of 0.5 volts. It has a single-ended output of 8, 32, and 64 ohms and balanced outputs of 100, 200, and 500 ohms. To avoid the use of an isolation transformer at the output and to minimize the effect of cable capacity, the 64-ohm

output was employed. At this impedance, a current of approximately 4 amperes is required for rated output. The keyer unit used was originally made for the NRL Long-Range-Search Sonar and is capable of developing pulse lengths of 3, 10, 30, 100, 300, 1000, and 2000 milliseconds. The unit has fixed preset delays both before and after the pulse. Closure of an initiating contact in an external program unit is required to trigger the pulsing circuits of the keyer. An external oscillator with power supply was used to supply 5, 8, and 10-kc signals to the keyer. As a transmit-receive device, a commercial-type vacuum relay was provided.

For receiving equipment, a preamplifier preceded by a high-pass filter, a narrow-band tunable receiver, and an oscillator, all of NRL design, with commercial power supply, was used. This equipment has a frequency range of 2.5 to 10.0 kc, bandwidths of 10, 25, 50, 75, or 100 cps, dynamic range of 40 db, gain of 87 to 146 db, a sensitivity of -152 db per volt in a 1 cps bandwidth at 50 ohms input impedance and an output impedance of 500 ohms. For calibration of the receiver gain and to tune the receiver, a calibrated signal from a frequency standard was supplied to the preamplifier. A pen recorder was used for recording the signal level from the receiver.

A Program Control Unit, modified from one used previously on the Long-Range-Search problem, provided ranges of 10 and 20 kiloyards and also contained the mechanisms for initiating the pulse to the keyer and for controlling the sweeps of the CRT (A-scan) displays.

Montioring equipment was provided to examine the level and wave shape of the transducer output (receiving), the receiving preamplifier output, and the driver output current and voltage. The monitor was also the source of the calibrated signal to the receiving equipment.

The output of the receiving preamplifier was recorded on magnetic tape.

The transducers used were a Raytheon magnetostrictive scroll, Figure 5, at 5 kc and the UQC underwater-telephone transducer at 8 and 10 kc. Patterns of these transducers within a 6000-pound towed body are shown on Figures 6 through 11. In the field, the 3000-pound fish was used; this housing-transducer combination is at present being recalibrated and measurements will be corrected if found necessary. Other characteristics of these units are given in references 2, 3, and 4. Each of these transducers is essentially omnidirectional. The presence of the lead keel and junction box of the fish distorted the pattern but it can be seen from the figures that corrections for directivity will be small.

OPERATIONS

The study, as originally contemplated using two ships (see Appendix A) was designed primarily to measure the surface scattering as a function both of the angle of arrival and the scattering angle. With the loss of the services of the second ship, the study as planned was abandoned and revised plans were devised to obtain as much information as possible from a single ship. Information concerning the self-noise of a deep-towed body, and the reverberation characteristics of sound propagated from a deep source was obtained. This information is vital to the complete understanding of any echo-ranging system that might be designed to use this path.

The measurements were made in an area just north of San Juan, in water where the depth was over 1000 fathoms; the sea state was less than 2. For the measurement of self-noise vs. depth at zero speed, the ship upon reaching the area, would come to a halt and stop all engines. The fish would then be lowered over the side and measurements taken at selected depths to a maximum of 3000 feet. A continuous record of noise vs. depth could not be obtained because at each depth the electrical cable had to be attached to make the measurement and detached before lowering to the next depth. The receiving amplifier was set alternately for 10-cycle and 100-cycle bandwidths and the information was displayed on a pen recorder. At the same time, the output of the preamplifier, which is broadband, was recorded on magnetic tape.

The self-noise of the towed body at a speed of 6 knots was also measured for a "length of line out" of 1000 feet. To make this speed, the ship operated its port engine only. The limitation of cable length to 1000 feet was made to provide a large factor of safety against the danger of entangling the towline in the screws of the ship when using a towed body weighing only 3000 pounds. Curves illustrating cable configuration and towing angle at the surface are shown in Figures 12 and 13. Computations show that it is possible to tow a body weighing 6000 pounds at a depth of 3000 feet, with the 5/8-inch-diameter towline, without such danger. In fact, it had been planned to use the heavier fish and one was available but because of mechanical difficulties with the hoist experienced during an earlier checkout prior to the San Juan exercise, it was decided to delay the use of this fish until a later date. The final exercise in the San Juan area was the continuous operation of the hoist with a 6000-pound fish for a period of 5 hours; however this was done at zero speed with a housing that was bereft of a transducer or junction box.

All reverberation measurements were made at zero speed. The depths were selected by using the bathythermogram as a guide. A typical BT showed an isothermal layer of 77° to a depth of about 300 feet, a gradual shift to a negative gradient during the next hundred feet and then a decrease to a temperature of about 65° at a depth of 900 feet. Reverberation measurements were taken at depths of 200, 1000, 2000, and 3000 feet, for pulse lengths of 10, 30, 100, 300, and 1000 milliseconds at 8 and 10 kc.

Incomplete data was obtained on the towing characteristics of the fish because of difficulties with the measuring circuitry and none is reported here. Visual observation of the satisfactory tow at shallow depths was possible. In fact the retrieving of the fish can only be accomplished while underway at minimum speed and stable towing is essential. The hoist itself operated very satisfactorily.

RESULTS

Self-Noise Measurements

Figures 14, 15, and 16 show the self-noise of the towed body at zero speed and at 6 knots as a function of depth. All noise levels are reduced to a one-cycle band, but not corrected for the directivity of the transducer within the towed body. It is not expected that the correction will exceed 5 db. (See transducer portion of equipment section). The transducers used in the field are at present undergoing recalibration to determine if any change in their characteristics occurred due to their immersion to a depth of 3000 feet. It was noted that the UQC transducer was slightly deformed after being subjected to this depth but with no change in its acoustical characteristics being apparent.

Since the absolute level of the self-noise cannot be given at this time, comparison to self-noise of other sonars and vehicles will not be made. Certain characteristics of the noise plots are of interest. There are regions where an increase in depth does not give a decrease in noise level. This region is different for the various frequencies measured. At 5 kc, between 60 feet and 200 feet, the level remains fairly constant. At 8 and 10 kc the region extends from about 100 feet to 400 feet. Within this region there also appears to be an increase of noise with depth. Such a characteristic of noise vs. depth has been noted before; the indications are that the increased level is due to a focusing of sound being propagated from the entire ship as a source.

The self-noise of the towed body underway at 6 knots, measured at 5 kc, is about the same level as at zero speed. It was expected that it would be at a higher level compared to zero speed such as was found for 8 and 10 kc. A repetitive sound, as might be caused by a vibrating cable, could be heard while listening through a broadband amplifier. An encouraging characteristic of this noise was that it changed from a steady repetitive sound at shallow depths to an intermittent sound at medium depths to a seldom-heard sound at the greater depths. This is interpreted to mean that the noise-generation characteristics of a bare cable decrease markedly with increasing length of line out.

All of the noise data show an over-all decrease of level with increasing depth.

It is probable that the noise measured at zero speed at 8 and 10 kc below 1000 feet represents the ambient noise level; it is also probable that if towing at 6 knots had been accomplished at depths greater than 1000 feet, ambient levels would likewise have been reached at a depth less than 3000 feet.

Several inconsistencies are apparent in the relative levels measured at the various frequencies. It is possible that recalibration of the UQC transducer may resolve this apparent inconsistency.

Reverberation Measurements

Measurements of reverberation strength at 10 kc showed a gradual drop off in received level. Measurements were made at a depth of 200 feet, (in a 300-foot isothermal channel), at 1000 feet, and at 2000 feet. The water depth was approximately 2000 fathoms and the bottom type was mud.

The average drop in reverberation level observed between 4000 and 8000 yards was: 8 db at a depth of 2000 feet, 9.5 db at a depth of 1000 feet, and 7.8 db in the channel at 200 feet.

Considering first the data taken at 200 feet, it was assumed that no divergence loss is operative on the outgoing pulse but that normal absorption and leakage losses occur. On the return trip, the full channel divergence loss in addition to the absorption and leakage losses were expected.

The reduction in reverberation level is then:

$$\left(10 \log \frac{R}{R_o}\right) + 2\,(\alpha_a + \alpha_k)\,(R - R_o)$$

α_a = absorption in db/kiloyard

R = range in kiloyards

R_o = initial measuring point (in kiloyards)

α_k = a scattering coefficient for reverberation (see NRL Report 4515)

The temperature in the channel was 77° F, the channel depth 300 feet, and the sea state 1. These conditions give:

α_a = 0.4 db/kiloyard

α_k = 0.22

The reduction in reverberation is then:

$$10 \log 2 + 2\,(.62)\,4 = 7.96 \text{ db}$$

This is in good agreement with the observed value of 7.8 db.

In the case of the measurements made at 2000 feet depth, the assumption was made that no ducting occurred.

The expression for the reduction in reverberation level would then be

$$20 \log \frac{R}{R_o} + 2\,\alpha_a\,(R - R_o)$$

In this case, the average temperature was estimated to be 68° giving an absorption coefficient of 0.5 db/kiloyard.

The calculated reduction in reverberation level is then:

$$20 \log 2 + 2 \times 0.5 \times 4 = 10 \text{ db}$$

This is 2 db greater than observed whereas it might have been expected to be lower if the surface-scattering coefficient is higher for larger grazing angles.

It is possible that considerable scattering into the channel occurred which would decrease the reverberation slope. It is also possible that the absorption coefficient is considerably less at the elevated pressure causing a lower observed value for reverberation slope.

In the case of the measurements made with a source depth of 1000 feet, arrival at valid assumptions on which to base a computation is most difficult. For computation purposes, it was decided to assume that the sound travelled to 4000 yards below the duct and from 4000 to 8000 yards in the duct. Under this assumption any sound arriving at the 8000-yard range would have to be scattered forward into the channel at 4000 yards. The loss between 4000 and 8000 yards was previously computed to be 7.96 db in the channel. This loss would be increased by the forward scattering coefficient. If the total loss due to forward scattering into the channel was 1 db each way, the observed results would be substantiated.

Since no satisfactory basis is available for assuming a forward scattering coefficient, no check on the validity of this measurement is attempted.

CONCLUSION

The previously discussed reverberation measurements are typical cases selected from the data. It is not considered worthwhile to present additional analyses since data taken with the source and the receiver located at the same point in the medium does not lend itself to this type of analysis.

As previously mentioned, data was taken in this manner only because one of the ships scheduled for this exercise was damaged enroute and could not participate.

The fact that good agreement with previous measurements in the channel was obtained only serves to point out the fact that very little has been done from below the channel.

The method for determining scattering coefficient illustrated in Figure 2 permits independent treatment of the angles of arrival and of scattering.

It is planned to reschedule such tests as soon as the necessary ships can be made available.

It is interesting to observe that the level of the reverberations measured from below the channel indicate that a considerable amount of energy was scattered into the surface-bounded duct. If subsequent measurements by more refined methods substantiate the low indicated loss in forward scattering, it would appear that a deep source would be as effective as one in the channel when the target lies in the channel.

The reverberation slope observed from a deep source was not radically different from that observed in the duct. This does not substantiate the expected increase in scattering coefficient with increasing angles. It is expected however that the use of more refined measurement methods will permit acquisition of data which can be analyzed to obtain scattering coefficients for all angles of arrival and scattering These values in turn should permit calculations of scattering loss (or gain) into the duct.

It should be observed that these results will be applicable to the skip-zone reverberation prediction as well as in deep source work.

* * *

REFERENCES

1. Buchanan, C. L., "A Reliable Acoustic Path Sonar," Journal of Underwater Acoustics, October 1956

2. USRL Calibration Report No. 1413 of 22 January 1957 (5 kc)

3. USRL Calibration Memo No. 264 of 9 December 1949

4. AT-186/UQC-1 Telephony Transducer Data Sheets of 6 February 1953

APPENDIX A

ASSIST SERVICES REQUEST FORM

PURPOSE

1. The object of the problem is to study propagation in the Reliable Acoustic Path (RAP) in order to determine the parameters of an experimental sonar system to be designed to utilize this path. The RAP to be investigated is that portion of the convergence zone propagation path beginning at a depth of 3000 feet and extending to the surface.

SCOPE OF TESTS

1. Two surface ships are to be used to obtain the experimental data, each equipped with a towed sonar equipment capable of towing a transducer at a depth of 3000 feet at a speed of 5 knots. The scope of the tests include:

(a) With one towed body at a depth of 3000 feet acting as the source, investigate the sound propagation at selected frequencies varying between 5 and 10 kc. The receiver is another towed body whose position is varied in range from source and in depth from surface.

(b) As an extension of (a) investigate the propagation from the deep into and along the surface bounded duct.

(c) Investigate propagation in the path reciprocal to (a) and in conjunction with (a) as a method of simulating echo-ranging by a prototype detection system towed at 3000 feet depth.

(d) Investigate surface reverberation and reflection characteristics considering possibility of target depth determination by prototype detection system.

(e) During the tests BT observations will be made from both ships.

2. Recommendations concerning tactics are not desired at this time.

3. Specific services requested are as follows:

(a) Two ships. It is requested that USS ROCKVILLE (EPCE(R)-851) and USS LSM-398 be assigned, as the towed sonar equipments have been designed for installation aboard these ships.

(b) Frequent voice communications between ships is essential. A clear radio channel for communications over a range of 15 miles is requested.

4. A submarine is not required at this time.

DESCRIPTION OF EQUIPMENT

1. Each of the ships will have similar towed sonar equipment capable of towing the bodies at any depth up to 3000 feet at speeds to 5 knots. The handling gear on the USS ROCKVILLE will be located approximately amidships on the starboard side (a similar gear has been used in the past successfully at this location). On the USS LSM-398, the handling gear will be located on the hoist platform and the towed body will be launched and retrieved through the centerwell. Hoisting speed is about 50 feet per minute; the towline (3500 feet long) is a 5/8-inch diameter special electric tow cable used without fairing or any other device to reduce vibration or drag. The towed body is just 70 inches long and weighs 5000 pounds.

The transducers are omnidirectional and operate at frequencies between 5 and 10 kc. Transmission, reception and display equipment will be standard in design; experimental electronic equipment will not be used at this time.

All equipment will be provided by NRL. The cost of installation will be borne by NRL.

2. NRL personnel will have all necessary instruction books and blueprints at the time of installation.

3. It is requested that all equipment be returned to NRL at the completion of operations.

4. Investigations of this specific nature have never been performed previously.

5. All personnel required to operate the equipment will be provided by NRL. It is estimated that four scientists will be assigned to each ship.

6. The installation will not affect the ship's habitability or characteristics.

STATUS OF EQUIPMENT

1. It is expected that all equipment will be ready for installation by 1 December 1956.

2. Shipyard or tender availability is not required. It is expected that the complete installation will be accomplished at NRL using NRL facilities if the ships are made available for a one month period.

3 and 4. The estimated cost of installation is $12,000. This will be borne by NRL.

REMARKS

1. First sea tests are planned to begin about 15 January 1957.

2. It is estimated that 40 operating days will be necessary to make the desired study. This is in addition to installation time.

3. NRL will provide all personnel for the installation and to make the field study. It is estimated that four scientists will be assigned to each ship during the study.

4. Liaison for this project will be:

LCDR M. J. Randleman, Code 1062, EXT. 2271

Mr. C. L. Buchanan, Code 5540, EXT. 712

Mr. I. Cook, Code 5544, EXT. 714.

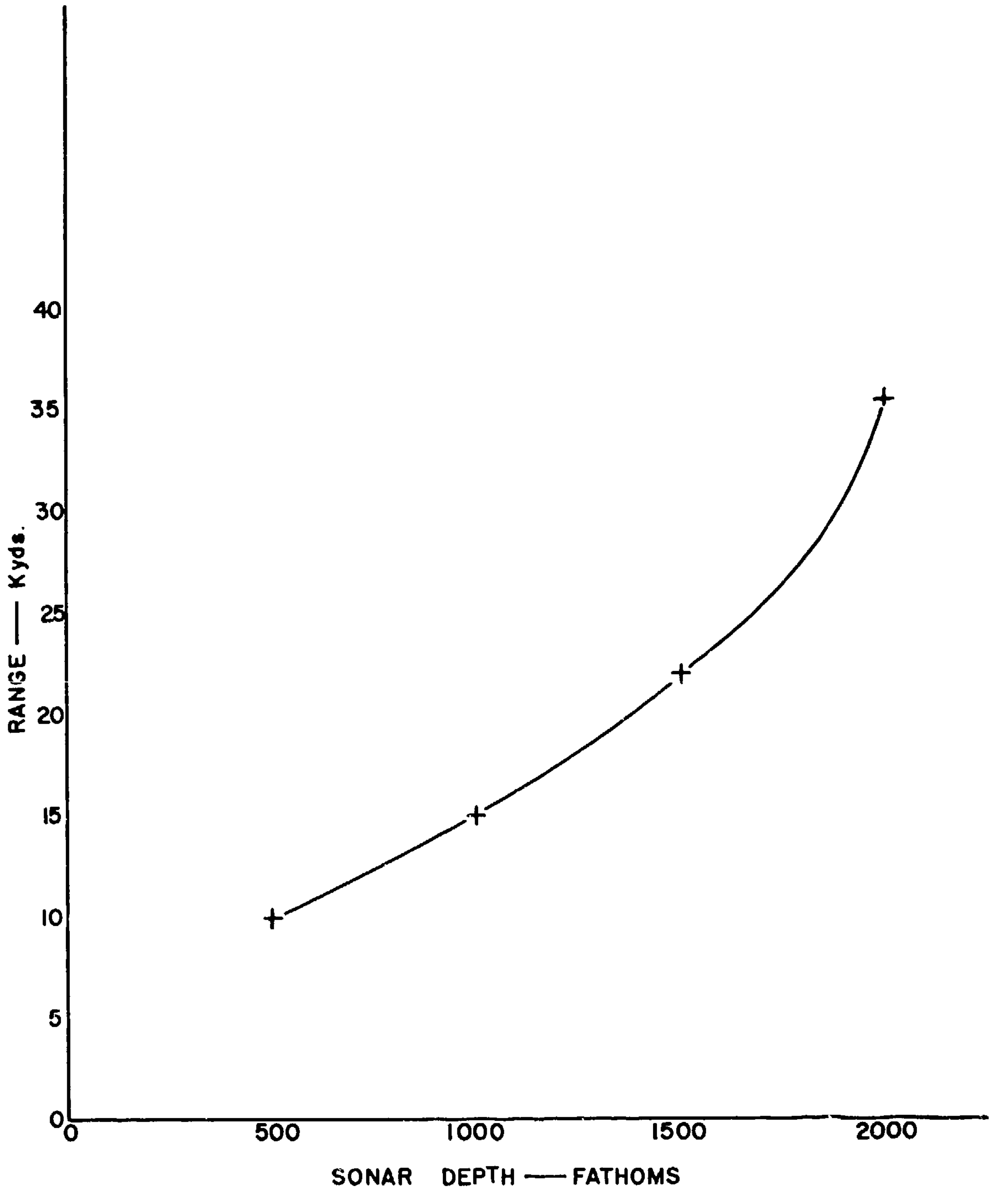
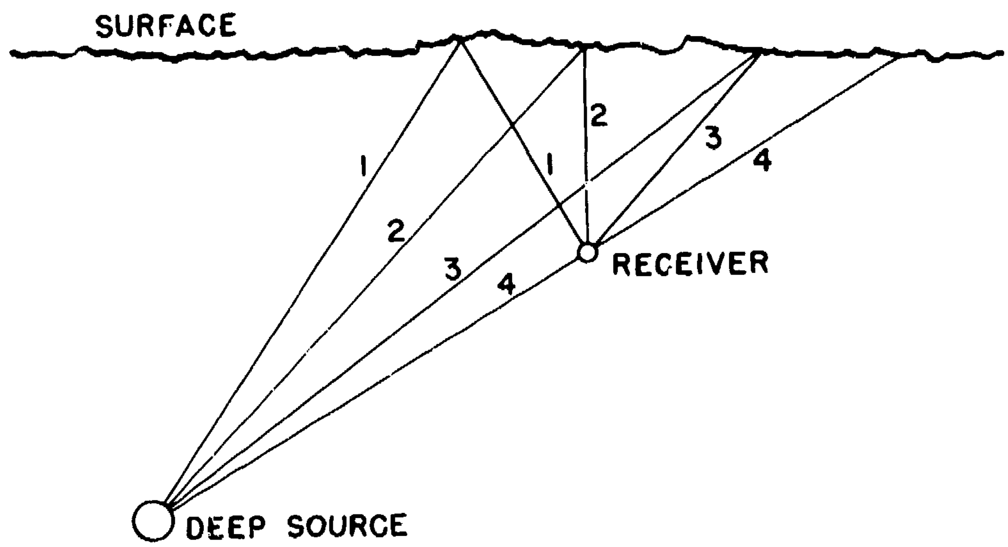
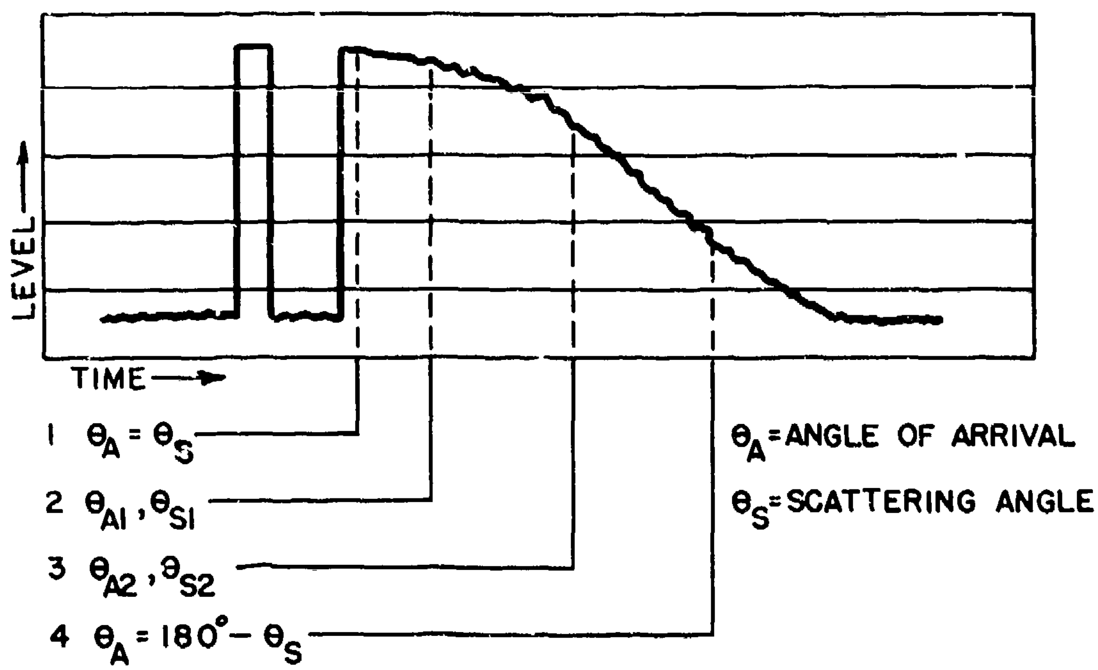


Fig. 1 - Estimated detection range for a deeply submerged sonar



(a)



(b)

Note -- The first part of the surface scattered signal received is the specularly reflected case

Figure 2 - Method for determining scattering coefficient at various angles

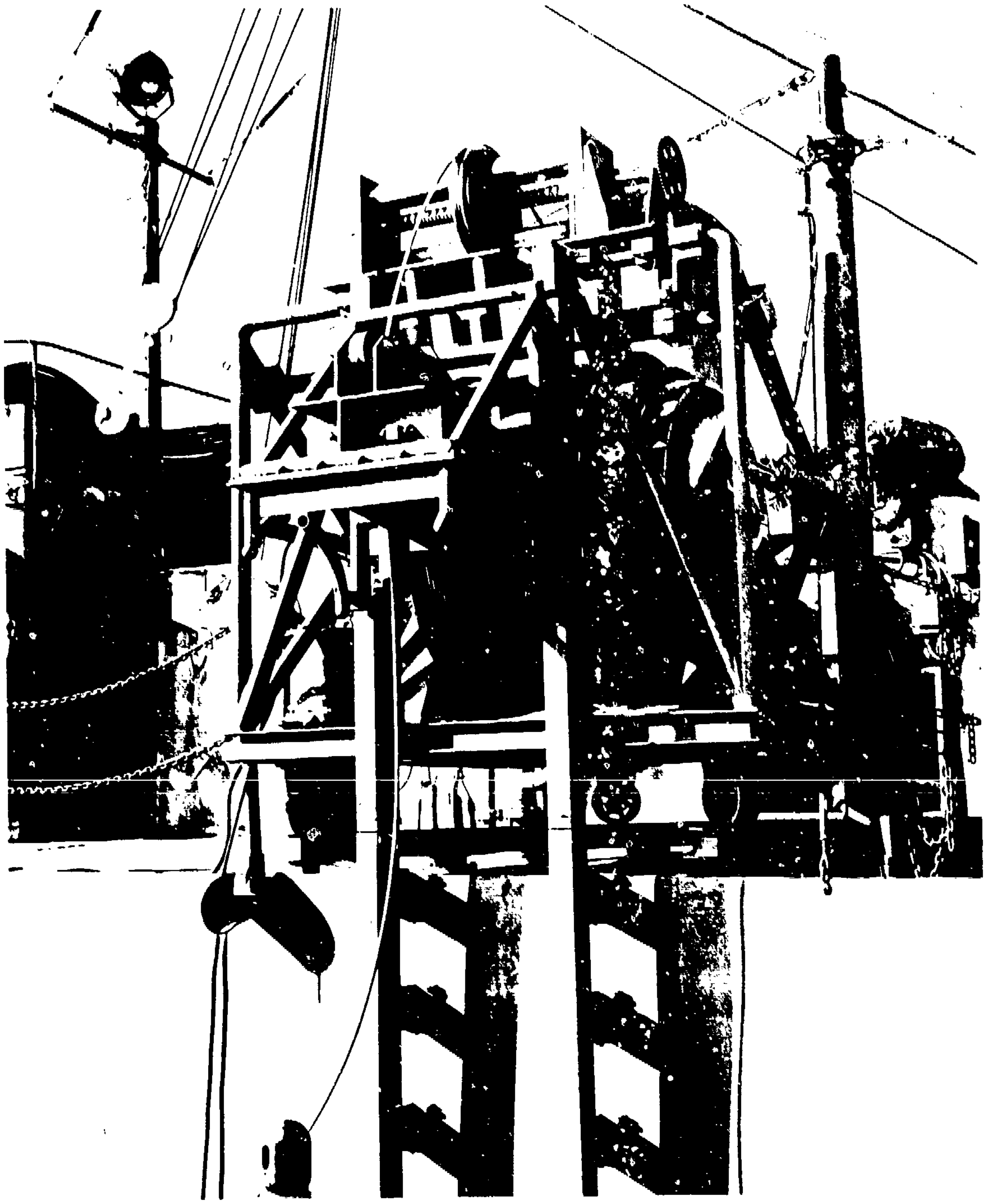


Fig. 3 - Hoist in operating position

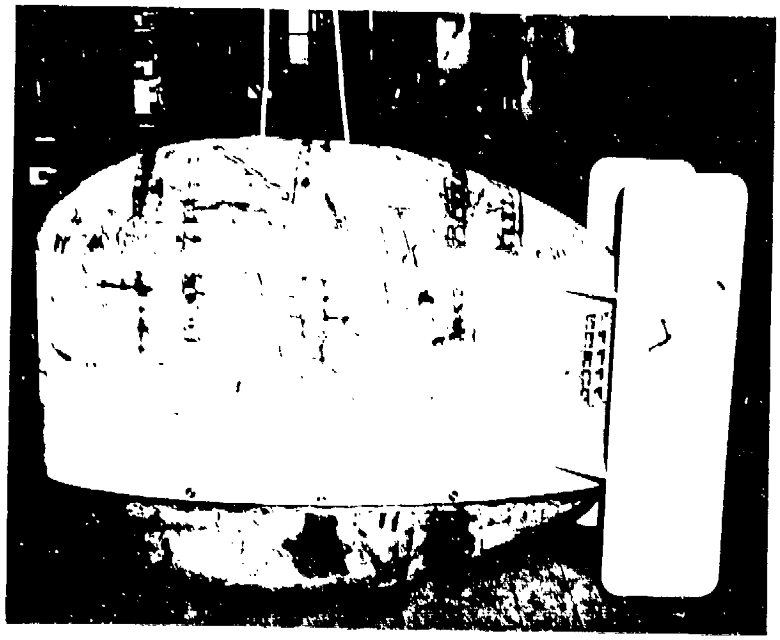


Fig. 4 - 6000-pound fish

Fig. 5 - 5-kc scroll transducer

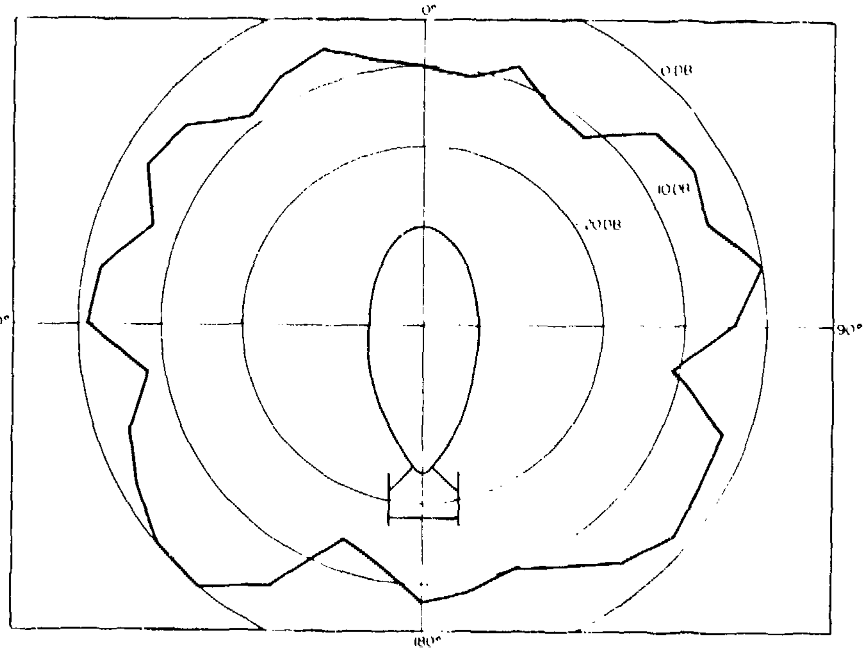


Fig. 6 - 5-kc receiving transducer (horizontal)

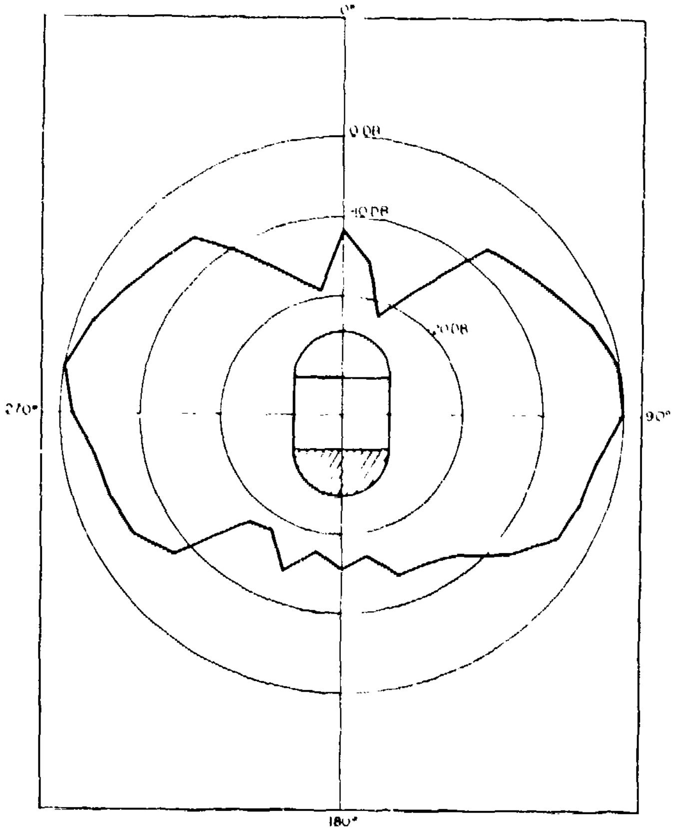


Fig. 7 - 5-kc receiving transducer (vertical)

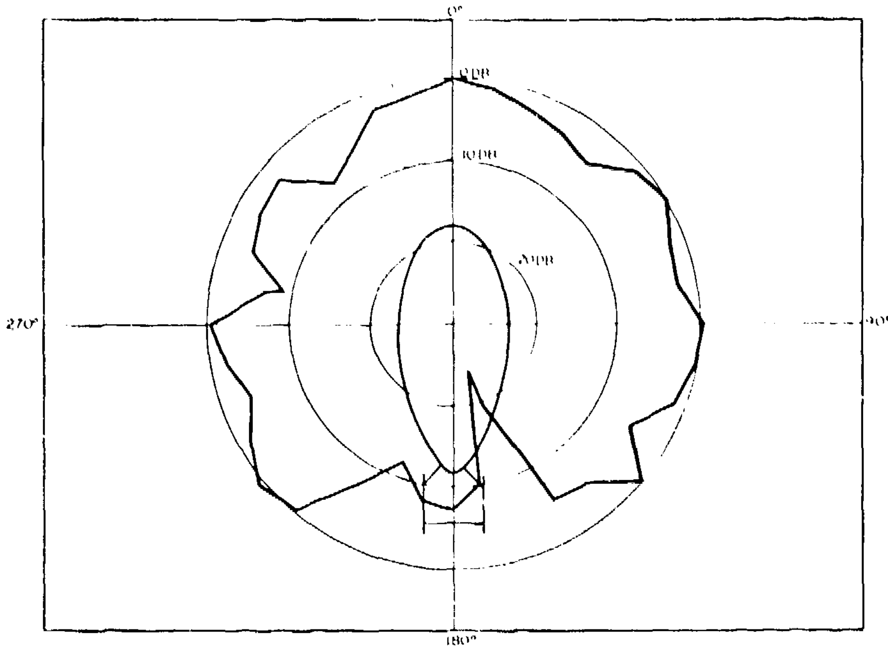


Fig. 8 - 8-kc receiving transducer (horizontal)

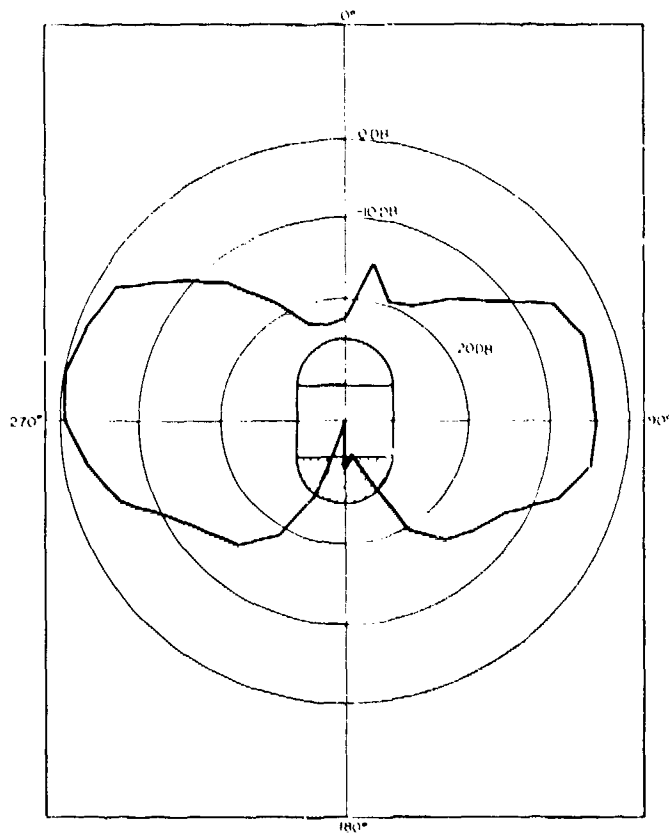


Fig. 9 - 8-kc receiving transducer (vertical)

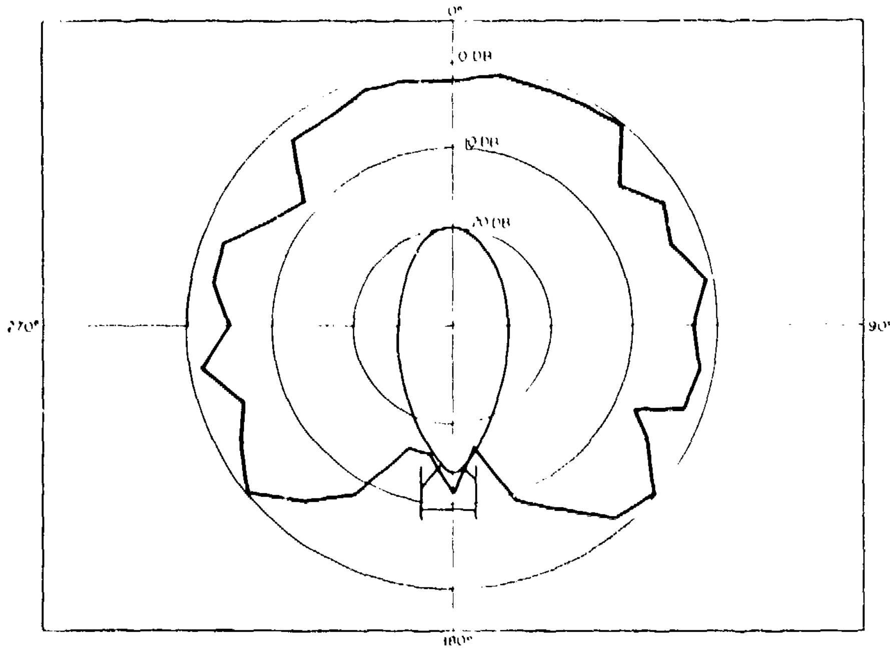


Fig. 10 - 10-kc receiving transducer (horizontal)

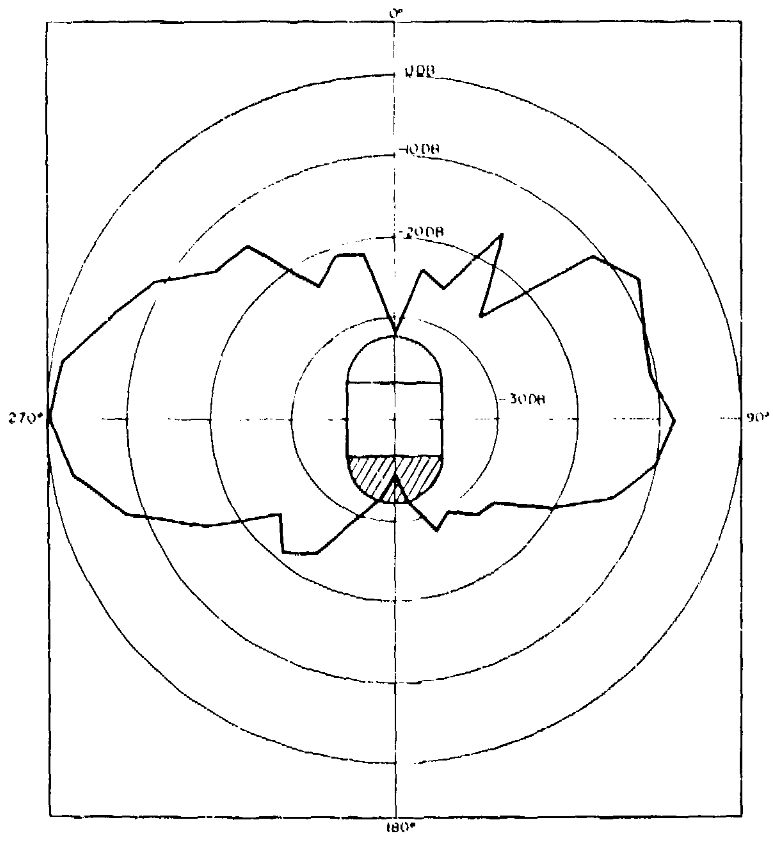


Fig. 11 - 10-kc receiving transducer (vertical)

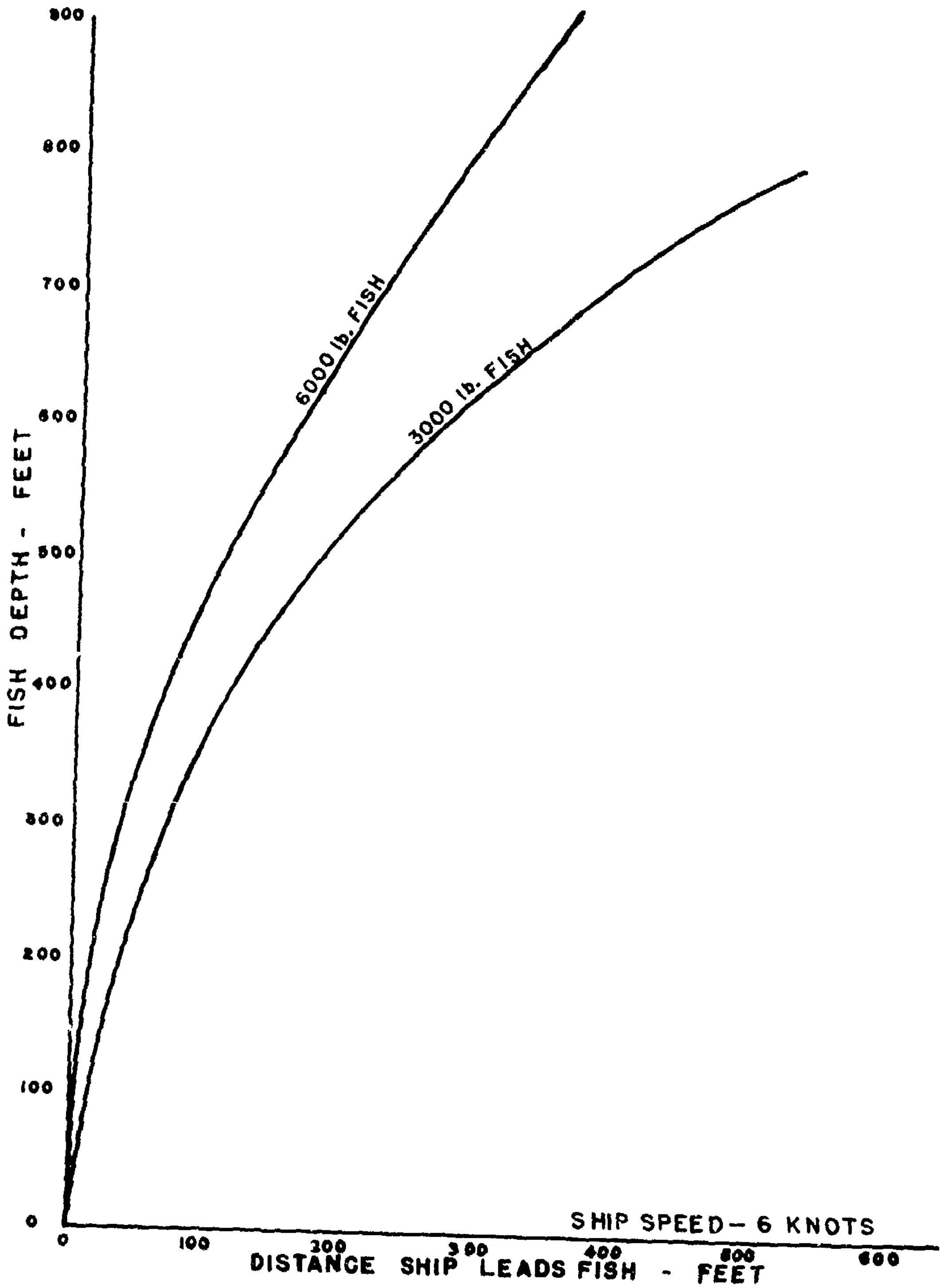


Fig. 12 - Position of ship relative to fish and cable configuration at any fish depth

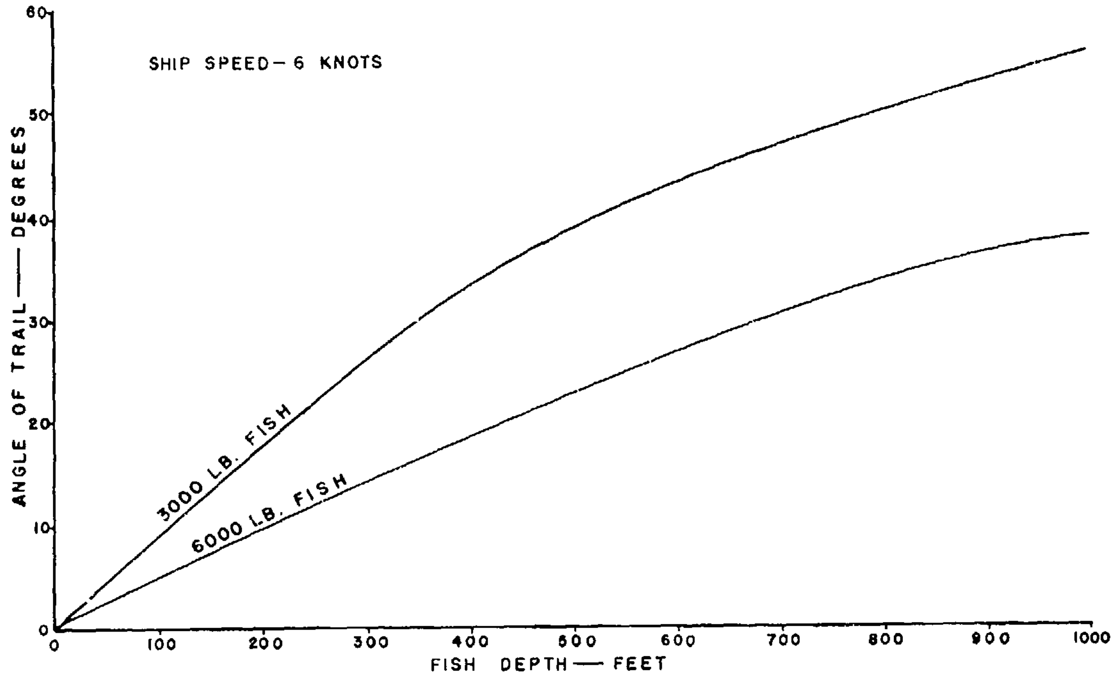


Fig. 13 - Angle of trail for fish depths to 1000 feet

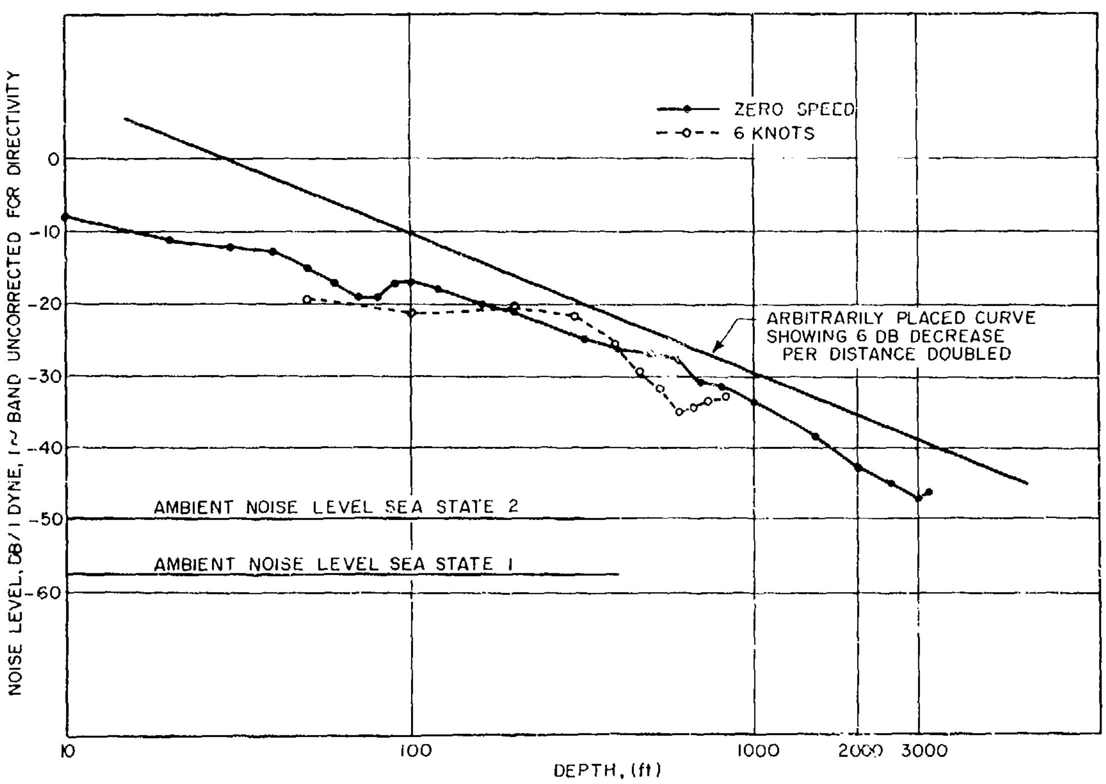


Fig. 14 - 5-kc self noise vs depth

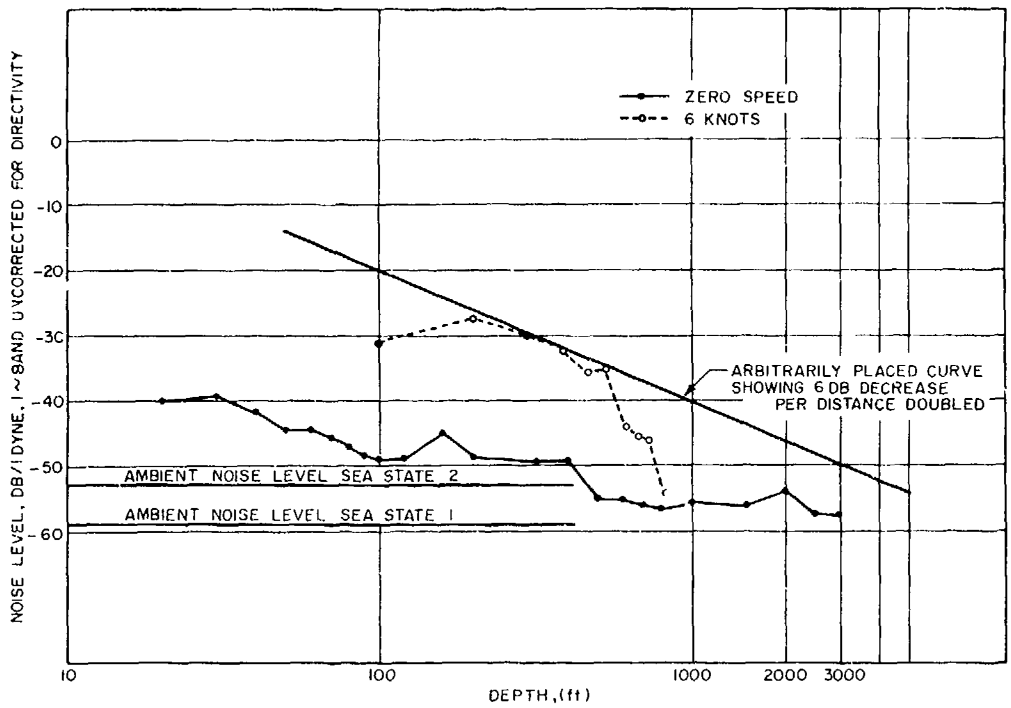


Fig. 15 - 8-kc self noise vs depth

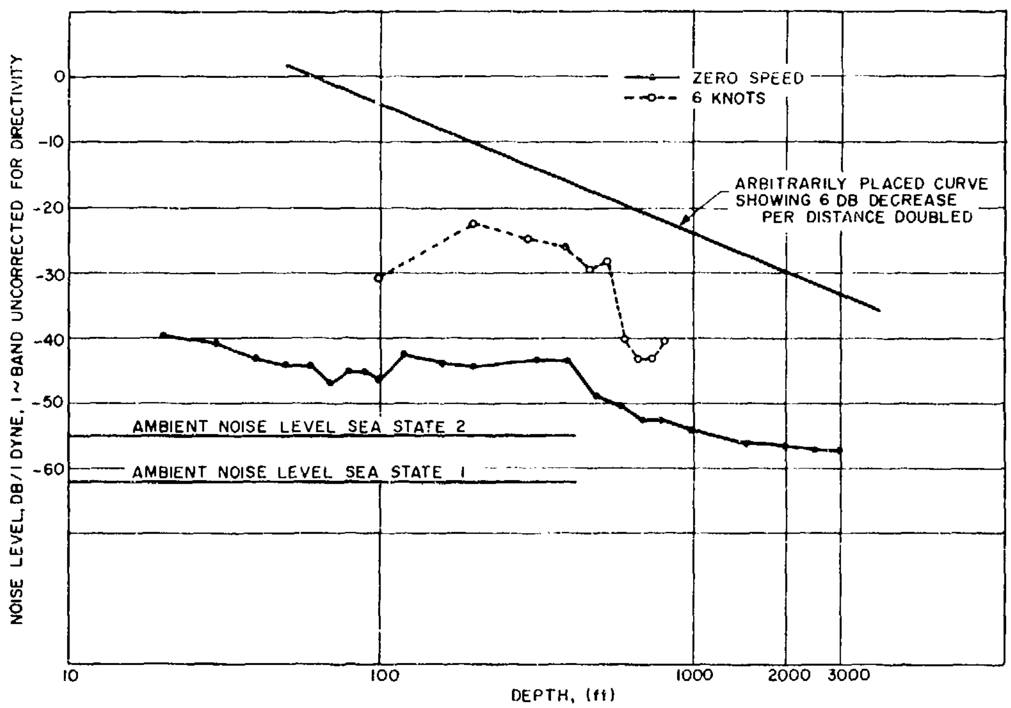


Fig. 16 - 10-kc self noise vs depth

UNITED STATES GOVERNMENT

memorandum

7103/129

DATE: 12 November 1996

FROM: Burton G. Hurdle (Code 7103)

SUBJECT: REVIEW OF REF. (a) FOR DECLASSIFICATION

TO: Code 1221.1

VIA: Code 7100

AD-C011 775

REF: (a) NRL Confidential Memo Report #700 by C.L. Buchanan and Isidore Cook, 17 Apr 1957

1. Reference (a) investigates the reliable acoustic path and the results of propagation measurements in the development of Long-Range Echo-Ranging Equipment that decreased the operating frequency of sonars following World War II. The major frequency of sonars during World War II was 25 kHz. The research and development at NRL following the war progressed to 10 kHz, 5kHz, and 2kHz. This report discussed the parameters to be considered in this process.

2. The technology and design of this development have long been superseded. The current value of this report is historical.

3. Based on the above, it is recommended that reference (a) be declassified with no restrictions.

Burton G. Hurdle

BURTON G. HURDLE
Acoustics Division

CONCUR:

Edward R Franchi 11/12/96

EDWARD R. FRANCHI Date
Superintendent
Acoustics Division